KEOMA: A Low Cost Alternative for Educational Robotics

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Abstract. *This article describes the KEOMA's development, a low cost robot. KEOMA is an interesting tool to contextualize the contents learned in class on a ludic way. The main aspect is the use of cheap electronic components and recycled material in its construction. KEOMA was experimented as a tool to teach programming concepts for Science and Technology students of the University of the State of Rio Grande do Norte (UERN). The results show an alternative platform used in educational robotics, making robotics more accessible, decreasing the complexity in its construction and making easier computer programming.*

1. Introduction

Robotics is gradually present in educational environments where students can assemble, disassemble and program a robot or a robot system. The use of these technologies produces an important impact on the learning process, providing ludic and attractive moments for teachers (or professors) and students. Educational Robotics offers an environment where students can handle, create and program, developing logical reasoning, which is really important for many areas of knowledge [Castilho 2002].

According to [Aroca 2012] and [Aroca et al. 2013], the most used robots in Educational Robotic are commercial platforms in which its costs are highly elevated. This actually makes difficult to practice of educational robotics in modest institutions and mainly by students without financial condition.

The use of KEOMA as an educational robotic platform can improve this scenario, giving opportunity for schools and students, mainly from public schools to be able to construct and develop their own robots using recycled materials and reusing electronic components. Furthermore, with this vision, we have a contribution to reduce electronic waste over the planet and to induce the Meta-Recycling.

This project aims to make easier access to a low cost robotic platform, Open Source and Open Hardware, as an alternative to high cost commercial platforms used nowadays, allowing to build a low cost robot, which can be used in large scale by schools, students, universities, researchers and roboticists. More details about the project can be found on [Santos, A. A. 2013].

In this paper, we also introduce a case study to show the feasibility and advantages of using KEOMA to teach programming concepts for students of Science and Technology course at University of the State of Rio Grande do Norte (UERN).

2. KEOMA Description

This section details the KEOMA robot. This platform has three parts: physical structure, hardware and software. The emphasis is to reuse electronic components, to recycle material and to work with Arduino platform in its construction, making KEOMA a low cost project, versatile, easy programming and simple circuit, which uses popular parts available in many stores, obsolete electronics and old toys.

2.1. Physical Structure

KEOMA physical structure was constructed by recycled materials. For the chassis we used an ADSL modem part, deodorant bottles Roll-on, plastic wheels from old toys and reused electronic components. Figure 1 presents details from KEOMA physical structure showing the reused materials.

Figure 1 – KEOMA physical structure details

KEOMA has two recycled plastic wheels (they have plastic bandages involving them, enabling the robot to move in ridged terrains), assembled on an ADSL chassis also recycled. Each wheel is actuated by a Mini Servo motor of 9g modified for rotation purposes. The motors receive control signal from Arduino platform, which receives data from devices such as Computers, Smartphones and Tablets connected by a Bluetooth connection module.

2.2. Hardware

As mentioned previously, the KEOMA platform uses Arduino technology as control center. With this device it is possible to command the servo motors and to provide information about KEOMA sensors. Furthermore, through Arduino Bluetooth module communication it is possible to send commands and to program remotely the KEOMA robot via Smartphones, Computers and Tablets.

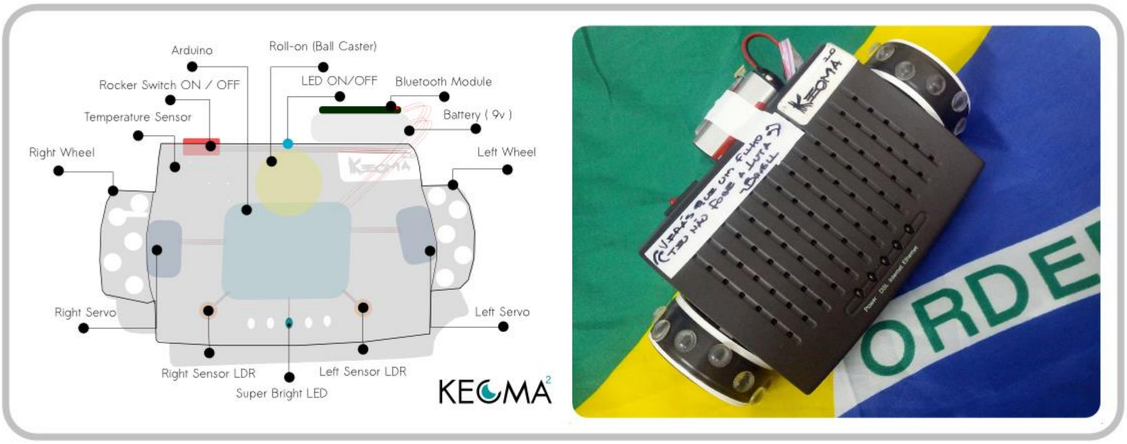

Figure 2 – Architecture general overview

2.3. Software

This section describes the Open Source solution to program the KEOMA´s microcontroller and the application developed to command it over Android devices.

Using an Open Source platform is the aim to program the Atmega328 microcontroller, and the usage of KEOMA joystick app, developed to command the KEOMA over Android devices.

2.3.1. Programming Environment

The programming environment to program the microcontroller of KEOMA is the Arduino Software, and a gcc compiler (C and C++) based in Wiring. The Arduino Software uses a graphic interface built in Java based in processing project. All functionalities are unified in an IDE (Integrated Development Environment) program Open Source very easy to use and easy to extend with libraries found over the Internet.

After building the program and compiling using IDE, the generated code is sent to the board via USB, where it is written inside the controller chip. The software which runs in the board is called FIRMWARE.

The IDE functions allow a software development and send it to the board for its execution.

2.3.2. KEOMA Joystick

KEOMA Joystick is an Android application based on BlueStick Control, developed within the objective to promote communication between KEOMA and other devices as Smartphones, Computers and Tablets, allowing to be commanded remotely through commands sent by these devices. Figure 3 shows KEOMA Joystick interface.

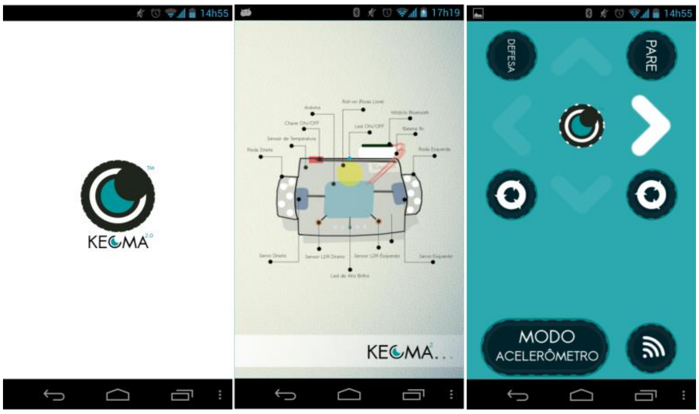

Figure 3 – KEOMA Joystick

3. Costs

This section shows the costs of the components necessary to build KEOMA, Table 1 shows a summary about building costs according to Brazilian stores with all fees. Table 1 also shows, in a comparative way, the value of these pieces in China, therefore it does not present the recycled ones.

The values suffer around 70% decrease in case of buying 10000 pieces, costing R$ 50,34 and US$ 23,97 for each unit respectively.

Table 1 – Costs of the material for KEOMA.

Unit(s) – Description	**Price (R$)**	**Price (US$)**
2 - Mini Servo 9g	15,55	7,00
1 - Arduino Nano v3.0	24,41	10,99
1 – Bluetooth Module	18,22	8,20
2 – LDR Sensors	4,00	1,80
1 – Temperature Sensor	4,50	2,02
1 – Battery (9v)	4,22	1,90
TOTAL	**R$ 70,90**	**US$ 31,91**

If we compare with one of the main solutions known in the wolrd, Lego® Mindstorms NXT® 2.0 8547, which costs R$ 1890,00 [Lego Brasil 2013], KEOMA is 95,77% cheaper.

4. Methods and Results

To validate KEOMA as an interesting alternative in teaching/learning process, researches with students of Science and Technology course (in the University of the

State of Rio Grande do Norte - UERN) were performed, analyzing qualitative and quantitative characteristics. Thus, we proposed challenges where students should solve problems by programming KEOMA, based on the knowledge acquired in the classroom and in a previous workshop giving basic KEOMA programming.

Questionnaires were administered before and after the challenges and the workshop to check the possible gains from the use of KEOMA.

4.1. Challenges

In the proposed challenges, students should solve problems by programming KEOMA based on the knowledge acquired in the classroom and in a workshop showing basic programming using the KEOMA. It had been launched three challenges addressing algorithmic language, basic instructions, and structure condition, repetition and interpretation algorithms.

4.2. Previous questionnaire

A previous questionnaire was made and showed that from 47 participating students: only 29.7% (14) felt encouraged to participate in class, 89.3% (42) remained in the classroom during the entire class time, 48.9% (23) claims to have good performance and dedication in learning, 34% (16) combines theory and practice and can correlate the content with the solution of real problems and 76.5% (36) participated actively in the activities developed in the classroom.

4.3. Later questionnaire

The same questionnaire was administered after the workshop using the basic programming KEOMA and challenges proposed (Figure 4 illustrates the gain over the previous questionnaire) showing a significant improvement of the students in relation to the previous questionnaire. In this new survey, 97.8% (46) felt encouraged to attend classes with KEOMA; 95.7% (45) remain in the classroom during the entire class time if KEOMA was used, 89.3% (42) deemed to have good performance and dedication in learning to use the KEOMA: 100% (47) combines theory and practice and can correlate the content with the solution of real problems when KEOMA is used, 100% (47) participate actively in the activities classroom if KEOMA were used.

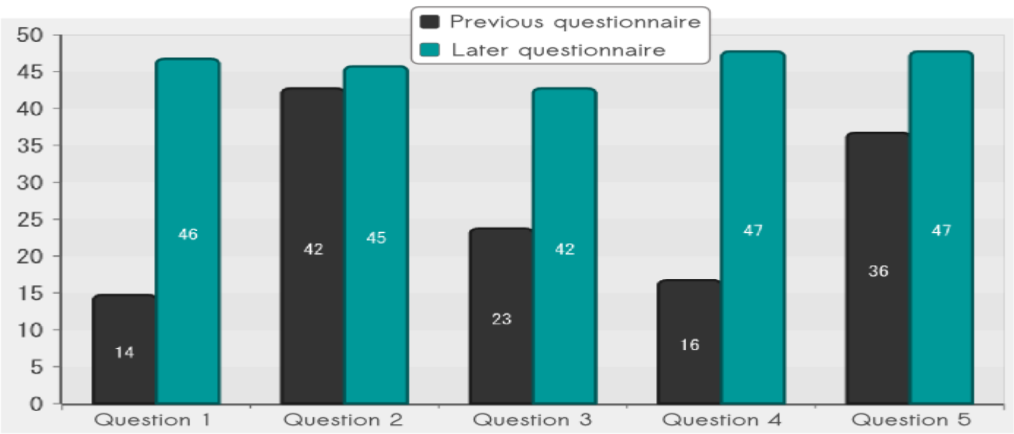

Figure 4 – Pros using KEOMA

4.4. Qualitative analysis

At the end, a final questionnaire gave students the opportunity to evaluate the benefits of using KEOMA in the teaching/learning with algorithm and programming and demonstrated interesting results.

From the 47 students, 100% (47) said that the use of KEOMA increased their interest in the discipline; 100% (47) understood and assimilated better the contents, 100% (47) said that the class with KEOMA became more dynamic, 100% (47) said that KEOMA captured interest; 93.6% (44) said that algorithm ans programming became clearer and 100% (47) considered positive using the KEOMA in learning course.

5. Conclusion

This article presented the KEOMA, a inexpensive, versatile, simple circuit and easy programming robot, which can be applied as an alternative educational robotics platform. We performed some experiments which demonstrated exciting results in the teaching/learning process, increasing the interest and motivation of students. Furthermore, the platform can help the students to understand and to have better assimilation of contents, making classes more dynamic and ludic.

In a ludic manner, KEOMA encourages the study and practice of the concepts learned in the classroom, which sometimes are not achievable only with the theory.

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